Soil Stabilization and Pile Formation Method

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Field of the Invention

The present invention relates generally to a method of securing a pile member in relatively unstable soil. More particularly, the present invention relates to a method of stabilizing a region of soil generally below a pile member to support the pile member thereon.

Background of the Invention

Methods are known for constructing piles in situ in somewhat unstable ground. The Bullivant patent, U.S. Pat. No. 4,605,339, for example, describes a method for forming a cast pile in unstable soil. Bullivant teaches casting a pile which extends through a layer of unstable soil into a region of stable soil. The pile itself is cast of concrete. The Bullivant method is not, however, useful in a soil site that does not have an accessible layer of stable soil. If the Bullivant method were used in such a soil site, the void created by the mole would not remain open. Further, the unstable soil below the desired pile location would not be able to support an end-bearing pile.

Summary of the Invention

The method of the present invention secures a pile member in generally unstable soil. This method makes useable locations that would otherwise be too unstable to support a structure. In particular, this method allows building upon soil that, at surface level, is extremely unstable and that sits on top of a layer of semi-stable soil.

According to a preferred method, a first tubular pile member is inserted generally vertically into the ground. The pile member is selected to be long enough to extend through the top extremely unstable soil layer and to terminate within the lower semi-stable soil layer. In a preferred method, the pile member is a steel pipe. A second small diameter injection pipe is inserted within the pile member and is positioned to terminate below the lower end of the pile member. The termination depth of the small diameter injection pipe isdetermined by soil conditions.

Grout is introduced through the injection pipe, under controlled pressure, as the injection pipe is withdrawn. The grout forms bulbs and lenses thereby compressing and stabilizing the material below the first tubular member providing support for the

first tubular member. The pile member is lowered into the grouted material. If desired, a reinforcing bar can be inserted into the first tubular member and into the stabilizing material.

When the grouted material cures, the pile member is securely embedded therein, and the grouted material below the pile member stabilizes the soil in the region below the pile member.

In another embodiment, a first tubular pile member is inserted generally vertically into the ground. The pile member is selected to be long enough to extend through the top extremely unstable soil layer and to terminate within the lower semi-stable soil layer. In a preferred method, the pile member is a steel pipe. Grout is introduced through the pile member, under pressure. The grout fills a space generally below the end of the first tubular member, thereby compacting the soil below the pile member. The grout spreads radially to some degree, thereby filling a space below the pile member that has a diameter generally larger than the diameter of the pile member. The pile member is lowered into the grouted material. When the grouted material cures, the pile member is securely embedded therein, and the grouted material below the pile member stabilizes the soil in the region below the pile member.

According to another aspect of this invention, a pile member includes a pipe, with compaction grouted material solidified below the end of the pipe. The grouted material compacts and stabilizes the soil beneath the pipe. This pile member is an end-bearing pile member rather than a friction pile member.

Brief Description of the Drawings

An exemplary version of a method for securing a pile member in unstable soil is shown in the figures wherein like reference numerals refer to equivalent structure throughout, and wherein:

FIG. 1 is a side sectional view of a pile member positioned to terminate within a semi-stable soil layer beneath an extremely unstable soil layer, according to a step in the preferred method of the present invention;

FIG. 2 is a side sectional view of a pile member with a second tubular member positioned therein, according to a step in the preferred method of the present invention;

FIG. 3 is a side sectional view illustrating the introduction of grouting material through the second tubular member according to a step in the preferred method of the present invention;

FIG. 4 is a side sectional view illustrating the pile member being lowered into grout material, according to a step in the preferred method of the present invention

FIG. 5 is a side sectional view illustrating the placement of a pile member according to an alternate embodiment of the method of the present invention;

FIG. 6 is a side sectional view illustrating the introduction of grout material according to the alternate embodiment of the method of the present invention; and

FIG. 7 is a side sectional view illustrating the pile member being lowered into grout material, according to the alternate embodiment of the method of the present invention depicted in FIGS. 5 and 6.

Detailed Description of Preferred Embodiment(s)

The method of the present invention converts an unstable soil arrangement that cannot support a significant load, such as a house or other building, into a buildable site. Such a soil site is depicted in FIG. 1. The site is characterized by a first upper layer of soil 10 that is extremely unstable, such as soil composed primarily of peat or soil that contains a relatively high volume of liquid. Below the extremely unstable soil is a second layer of soil 20 that is more stable than the upper layer 10, but still too unstable to support a pile or foundation member for a building. This method can be used in soil sites where the first layer 10 is any depth. Typically, the depth of such a layer is between 10 and 100 feet, and most commonly between 20 and 40 feet.

In a first preferred embodiment of the present invention, a tubular member 30 is introduced into the soil deeply enough that its terminating end 35 is within the second layer 20, i.e. end 35 extends below the first soil layer 10. Because the soil layer 10 is so soft or compliant, the tubular member 30 can be easily lowered through layer 10 into layer 20 without the use of drilling equipment or specialized moles or the like. In a preferred embodiment, tubular member 30 is a steel pipe having a diameter of between 4 to 6 inches, though those of skill in the art will recognize that tubular members of other materials and sizes will work according to the method described. The length of tubular member 30 is selected such that it extends from above the upper surface of layer

10 to below the first layer of extremely unstable soil 10, such that tubular member 30 terminates within the second soil layer 20.

After positioning the first tubular member 30, a second tubular member or injection pipe 40, having an outer diameter that is less than the inner diameter of first tubular member 30, is inserted through said first tubular member, and lowered until its terminating end 45 is positioned within the second soil layer 20, and preferably below the terminating end 35 of first tubular member 30. This is illustrated in FIG. 2. In a preferred method, terminating end 45 of second tubular member 40 is positioned between about 6 and 10 feet below the terminating end 35 of first tubular member 30.

As shown in FIG. 3, grout material 50, such as cement-based grout, is introduced through second tubular member 40. Preferably, the grout 50 is pumped under controlled pressure through tubular member 40. The grout material 50 is deposited at the terminating end 45 of second tubular member 40. Second tubular member 40 is then withdrawn, or moved upwardly. As the tubular member 40 is raised, grout material is continually pumped therethrough under controlled pressure and is deposited at the terminating end 45. In this manner, a column 60 of grouted material 50 is formed. The column 60 includes bulb and lens formations.

Finally, first tubular member or casing 30 is lowered into the grouted material 50, as illustrated in FIG. 4, in the direction indicated by arrow 75 into the grouted material 50. When the grouted material 50 cures, it provides a stabilized soil region to support the pile member 30. Because of the characteristics of the second soil layer 20, the grouted material remains relatively close to its deposit site and therefore forms a column 60 as the second tubular member 40 is withdrawn and grout material is simultaneously supplied.

In an alternate embodiment of this method, illustrated in FIG. 5, a first tubular pile member 130 is inserted through extremely unstable soil 110 such that the pile member's terminating end 135 is positioned within a second soil layer 120. As illustrated in FIG. 6, grout material 150 is introduced through pile member 130. The grout material is deposited within the soil in the second soil layer 120 generally below the pile member 130. Finally, as illustrated in FIG. 7, pile member 130 is lowered, in the direction indicated by arrow 175, into the grouted mass 180.

Use of the second tubular member or injection pipe 40 allows use of a shorter casing 30. This is useful where there is low headroom or where the second soil layer

120 is too soft or unstable to provide any kind of end bearing for a cementatious bulb at the bottom of the pile, such as when the casing is installed though unstable material and terminates in a stable material.

Although an illustrative version of the method is shown, it should be clear that many modifications to the method may be made without departing from the scope of the invention.